

Chromosome polymorphism in *Sorex alpinus* (Mammalia, Soricidae) in the western Alps and the Swiss Jura

By E. DANNEID

Institut de Zoologie et d'Ecologie Animale, Université de Lausanne, Lausanne, Switzerland

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Abstract

The karyotype (chromosome morphology and G-banding pattern) was examined in 15 individuals of *Sorex alpinus*, the alpine shrew, collected in southwest Switzerland and neighbouring France. All three recorded chromosome numbers, $2N = 58, 56$ and 54 , occur within Switzerland. It was found that this difference in chromosome number is due to Robertsonian polymorphism. Polymorphism in the number of acrocentric versus subtelocentric chromosomes may also occur.

Introduction

The shrew *Sorex alpinus* is distributed in the mountainous areas of Central and Southern Europe: i.e. the Alps, the Carpathians, the mountains of the western Balkan Peninsula, the Swiss Jura, and some mountainous areas further north in Germany (Schwarzwald, Harz, Fichtelgebirge etc.). There is also one doubtful record for the Pyrenees. The records of distribution are taken from SPITZENBERGER (1990). Morphologically, *Sorex alpinus* seems to be very distinct from other *Sorex* species and it occupies a rather isolated position within the genus, even though comparisons between *S. alpinus* and the East Asian species *S. mirabilis* have been made. These similarities were mostly due to the shape of the glans penis (HUTTERER 1982). Allozyme data also sets *S. alpinus* clearly apart from other *Sorex* species (CATZEFLIS et al. 1982; CATZEFLIS 1984).

The karyotype of *Sorex alpinus* is not well known, REUMER and MEYLAN (1986) give $2N = 54-56$ (CATZEFLIS et al. 1982), 56 (ZIMA and KRÁL 1984) and 58 (MEYLAN 1964, 1966). More recently, ZIMA and KRÁL (1990) again recorded $2N = 56$ for the species. This is a higher chromosome number than in any other Eurasian *Sorex* (except for the members of the *Sorex cinereus*-group in extreme northeast Siberia). Also most chromosomes seem to be acrocentric although no definite statement of the NF-number has been made. This karyotype differs greatly from others known in Eurasian shrews. To the author's knowledge no banding of any kind has ever been published on the chromosomes of this species. In the present study a description of the chromosome set of *S. alpinus* (including G-banding) is given.

Material and methods

The material used consisted of 15 shrews (13 from the Swiss and the French Alps, 2 from the Swiss Jura), 6 males and 9 females, trapped between November 1980 and December 1992. For details regarding sites and dates, see figure 1 and table 1. The chromosomes were prepared by the direct method from spleen and bone marrow. Colchicine was applied for a period varying from 45 to 60 minutes. The preparations were left for 3 days, after which they were digested with trypsin, using a modified form of the method described by SEABRIGHT (1971). G-banding was performed on 11 of the individuals. The terminology for the chromosomes follows LEVAN et al. (1964), thus acrocentric chromosomes are termed $t1$, $t2$ etc.

Results

All three reported diploid numbers of chromosomes, $2N = 58$, 56 and 54, respectively, were found among the investigated animals. Four animals (all females) had a diploid number of 58 chromosomes. They were trapped in the Swiss Alps, east of Lake Geneva and north of the Rhone Valley, in the cantons Vaud, Valais and Bern (Fig. 1). Three animals (one male and two females) had a diploid number of 56 chromosomes. Two of these animals were trapped in the Swiss Jura, the third in the Swiss Alps southeast of Lake Geneva, in canton Valais, south of the Rhone Valley (Fig. 1). Eight animals (five males and three females) had a diploid number of 54 chromosomes. These animals were trapped in the Swiss and French Alps, south of Lake Geneva (Fig. 1).

Description of the chromosome formula

The 58-karyotype: There was only one pair of large metacentric chromosomes, two pair of medium-sized subtelocentric chromosomes, one pair of small biarmed chromosomes and 24 pairs of acrocentric chromosomes. The X-chromosome was a large submetacentric. Since all investigated animals were females, the Y-chromosome was not known. One individual had one acrocentric pair less, but two pairs of small biarmed chromosomes instead of one pair.

The 56-karyotype: This karyotype differed from the 58-type in that there was one additional pair of large metacentric chromosomes and only 22 pairs of acrocentric chromosomes. The Y-chromosome was possibly acrocentric.

The 54-karyotype: This karyotype differed in that there were three pairs of large



Fig. 1. Location of trapping sites for the animals used in the study

Table 1. Data of the animals used

IZEA number	Sex	2N	Date of capture	Locality
989	female	56	06. 11. 1980	Bassins, Vaud
999	female	56	15. 07. 1981	Le Vaud, Vaud
3051	female	54	16. 10. 1987	Les Houches, France
3053	male	54	09. 11. 1987	Les Allamands, France
3300	female	58	25. 08. 1988	Bärfel, Oberwald, Valais
3421	male	54	20. 12. 1988	Les Houches, France
3422	female	58	20. 12. 1988	Innertkirchen, Haslital, Bern
3780	male	54	15. 11. 1989	Les Houches, France
4330	male	54	02. 09. 1991	Champéry, Val d'Illeiez, Valais
4331	female	54	02. 09. 1991	Champéry, Val d'Illeiez, Valais
4705	female	58	09. 09. 1992	Innertkirchen, Haslital, Bern
4709	male	56	21. 09. 1992	Mase, Val d'Hérens, Valais
4710	female	58	01. 10. 1992	Pont-de-Nant, Vaud
4713	male	54	16. 10. 1992	Champéry, Val d'Illeiez, Valais
4732	female	54	02. 12. 1992	Les Houches, France

Note: the numbers given for the two first animals are not IZEA-numbers, they refer to a collection made by FRANCOIS CATZEFLIS, and stored at the Institut de Zoologie et d'Ecologie Animale in Lausanne.

biarmed chromosomes (two metacentric and one submetacentric) and only 20 pairs of acrocentric chromosomes. The Y-chromosome was small and probably biarmed.

The G-banding pattern

The G-banded pattern of the chromosomes is shown in figures 2 and 3. The G-banding showed that of the two large metacentric pairs, the one here called m2 was present in all animals. The pair m1 occurred in 54- and 56-animals and was formed by a fusion between the acrocentric chromosomes called t9 and t11 in 58-animals. Finally, the large submetacentric pair (sm1) occurring only in 54-animals was formed by a fusion between the acrocentric pairs called t4 and t20 in other animals. The relative length of the different chromosomes is given in table 2.

Discussion

Robertsonian polymorphism

The different diploid numbers of chromosomes in *Sorex alpinus*, 58, 56 and 54, respectively, were invariably connected with different numbers of large biarmed autosomes (note that the X was also large and biarmed), one pair in the 58-type, two pairs in the 56-type and three pairs in the 54-type. It may be noted that ZIMA and KRÁL (1990) found 56 chromosomes and that "the female karyotype contained three pairs of large biarmed chromosomes", of which one was obviously the X-chromosome, in *Sorex alpinus* from Czechoslovakia. Thus, it seems highly plausible that the difference in chromosome number within the species is due to Robertsonian translocations.

G-banding analysis confirmed this. Of the three large biarmed pairs of autosomes the pair m2 was present in all animals. The pair m1 was present in 56- and 54-animals and formed by the acrocentric pairs t9 and t11 in 58-animals. The pair sm1 was present only in 54-animals and was formed by the acrocentric pairs t4 and t20 in the other animals.

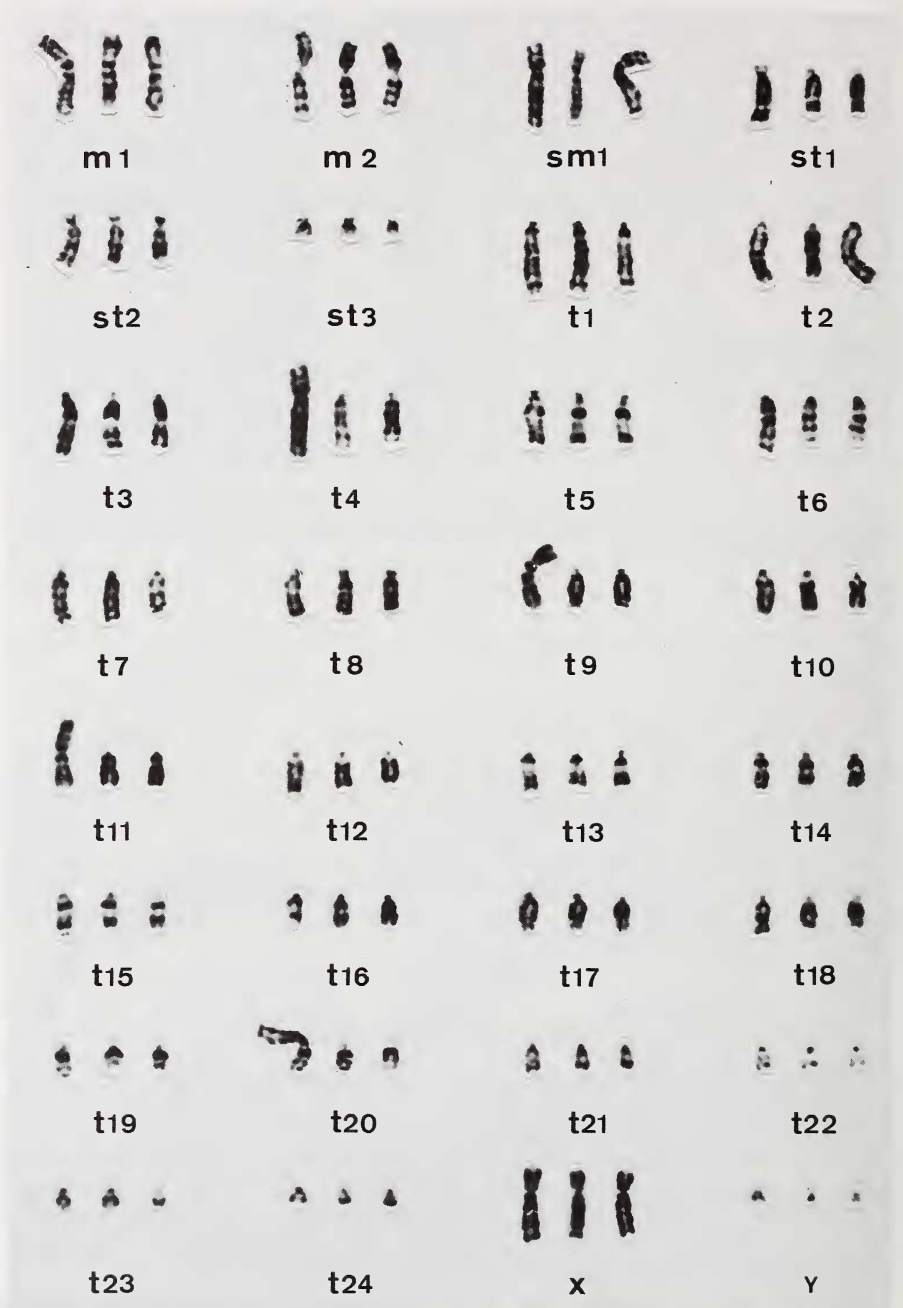


Fig. 2. G-banded chromosomes of *Sorex alpinus*. Three different specimens of each chromosome are shown. For the acrocentric chromosomes involved in Robertsonian fusion, the fusion is also shown

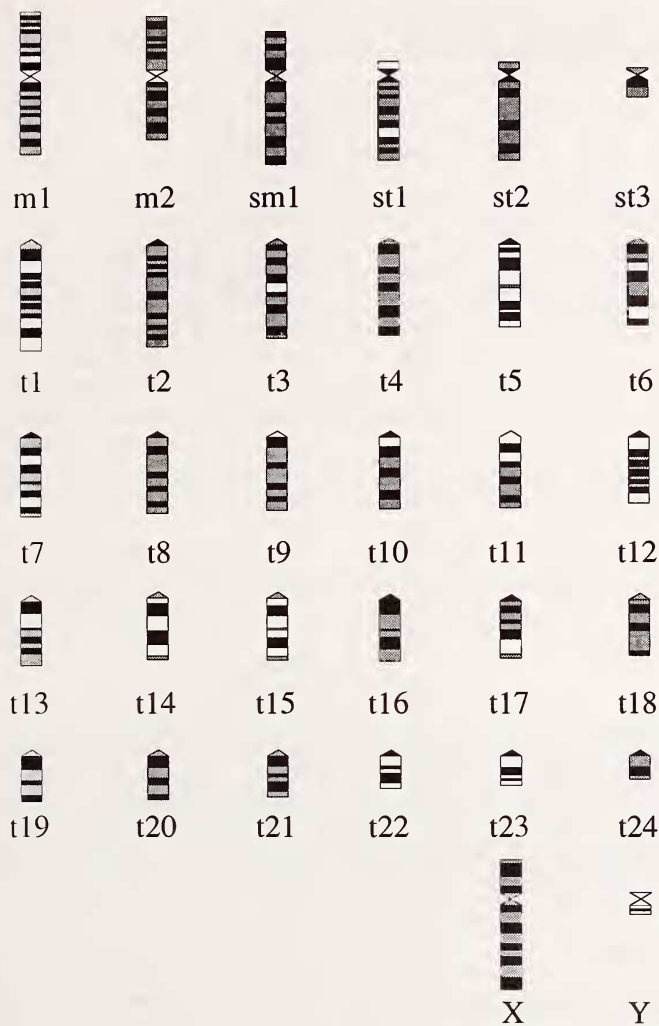


Fig. 3. G-banding pattern of the chromosomes of *Sorex alpinus*

It is generally agreed that in mammals, centric fusion is a much more common process than centric fission. This idea should lead to the hypothesis that the 58-karyotype is the most primitive character state, and that a fusion between pair t9 and pair t11 gave rise to the 56-karyotype. Another fusion, this time between pair t4 and pair t20 led to the 54-karyotype.

The material examined in this study is probably too small in number to determine whether the variation in chromosomal number is geographically correlated (as seems probable). However, at least the 54-karyotype seems to have a specific geographical distribution. It was the most frequently encountered, eight animals, all captured in an area south of Lake Geneva (chiefly Les Houches in French Savoia and Val d'Illiez in canton Valais) where all animals had the 54-karyotype.

The 58-karyotype was encountered in animal east of Lake Geneva, from Haslital in

Table 2. Length of chromosome arms
(in mean percentage of length of female haploid set)

	Shorter arm	Longer arm	Total
m1	3.43	3.52	6.95
m2	2.86	3.00	5.86
sm1	2.11	4.42	6.53
st1	0.52	3.50	4.02
st2	0.48	3.53	4.01
st3	0.36	1.02	1.38
t1			5.52
t2			5.22
t3			5.18
t4			4.55
t5			4.45
t6			4.35
t7			3.95
t8			3.88
t9			3.55
t10			3.55
t11			3.37
t12			3.19
t13			3.16
t14			3.16
t15			2.97
t16			2.93
t17			2.87
t18			2.85
t19			2.30
t20			2.25
t21			2.17
t22			1.69
t23			1.52
t24			1.37
X	1.89	4.03	5.92
Y			0.62

canton Bern in the north to Pont-de-Nant in canton Vaud in the south- and east to Bärfel, Oberwald in canton Valais. These localities were all situated north of the Rhone Valley. The sample consisted, however, of only four individuals.

The 56-karyotype, finally, presents some problems. Of the three individuals, two were captured in the Swiss Jura, north of Lake Geneva, while the third was from Val d'Hérens in canton Valais, which is south of the area with 58-animals. Finally, it exists in Czechoslovakia (ZIMA and KRÁL 1990). It may be noted that the material analysed by ZIMA and KRÁL (1990) originated from two geographically isolated distribution areas, in the Carpathians in Slovakia and in the Jeseníky Mountains in Czechia.

Previous results from MEYLAN (pers. comm.) seem to indicate that neither the distribution of the 54-karyotype nor that of the 58-karyotype is geographically homogeneous.

However, the data in this study suggest that the distribution of the three different karyotypes is geographically correlated, and assuming this to be true, two alternative hypotheses may be formed.

The first hypothesis is that the 58-karyotype is the most ancient and via centric fusions has given rise to the 56- and 54-karyotypes, as suggested above. In this case the original 58-karyotype has been replaced by the 56-karyotype south of the Rhone and further westward (and northeastward).

The 54-karyotype then arose from the 56-

karyotype in the area south of Lake Geneva, thus separating the 56-populations of the Jura from those of the Alps.

The second hypothesis takes into account the large and nonhomogeneous distribution of the 56-karyotype. However, genetically it seems to be constant. By studying banded material from western Czechia (Sumava mountains) it was possible to confirm that the fusion of t9 and t11 into m1 is the same there as in the Jura and in Valais south of the Rhone Valley. This hypothesis should thus be that the 56-karyotype is the most ancient, and has given rise to the 54-karyotype (via centric fusion) and to the 58-karyotype (via centric fission).

It would be interesting to compare these karyological data with differences in morphology and electrophoresis from the different areas. Unfortunately, very few publications have been concerned with *Sorex alpinus*. CATZEFLIS et al. (1982) found electrophoretic polymorphism in this species (6 loci out of 17 studied); all their individuals were, however, from one locality (Pont-de-Nant in canton Vaud). Moreover, CATZEFLIS (1984) again reported polymorphism in *Sorex alpinus*; animals from Pont-de-Nant (which should have

the 58-karyotype) had 5 polymorph loci (out of 35 studied), while in animals from the Swiss Jura (which should have the 56-karyotype) only one polymorph locus (not polymorph in Pont-de-Nant) was found.

Other polymorphies

ZIMA and KRÁL (1990) recognized two pairs of subtelocentric chromosomes in this species. Actually, there are probably more than two pairs of subtelocentrics (excluding the tiny st3). In some Giemsa-stained preparations up to six could be distinguished. In some metaphases almost all autosomes appeared to be biarmed, and ZIMA recorded the same condition for the Czechoslovakian material (ZIMA, pers. comm.). However, only pairs st1 and st2 (in size order corresponding closely to the two pairs described by ZIMA and KRÁL (1990) and thus probably identical with these) were easily recognized, moreover, these two pairs were the only ones possible to identify as subtelocentrics also in the G-banding. The other chromosomes sometimes appearing as subtelocentrics quite as often were acrocentric. This non-constant condition might be due to centromeric shift, or to different interpretation because the smaller arms are sometimes exceedingly difficult to see, especially if the chromosome is in a contracted state. A possible third subtelocentric pair might be the pair here termed t8.

To ascertain whether the distribution of the 58-, the 56-, and the 54-karyotypes is geographically correlated and in that case to determine the distributions greater detail, further studies on the karyology on this species are needed, also from other parts of its distributional area.

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Zusammenfassung

Chromosomenpolymorphismus von Sorex alpinus (Mammalia, Soricidae) in den Westalpen und im Schweizer Jura

Der Karyotyp von *Sorex alpinus* wurde für 15 Tiere anhand der Chromosomenmorphologie und des G-Bandenmusters analysiert. Alle drei bisher bekannten Chromosomenzahlen $2n = 58, 56$ und 54 wurden für die Schweiz nachgewiesen. Ebenso konnte gezeigt werden, daß der Unterschied in der Chromosomenzahl durch einen Robertsonischen Polymorphismus bedingt wird.

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Author's address: ERLAND DANNEID, Department of Zoology, Stockholm University, S-106 91 Stockholm, Sweden